FINAL REPORT FOR RESEARCH AGREEMENT
#INT-93785-RJVA
University of Montana
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Evaluation of Uneven-Aged Silviculture and Underburning for Managing Ponderosa Pine/Douglas-fir Forests in Montana

FINAL REPORT

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This final report summarizes work on Research Joint Venture Agreements INT-91616-RJVA and INT-93785-RJVA between the Intermountain Research Station (Clinton Carlson - ADOR), and the University of Montana (Carl Fiedler - Principal Investigator) for the period spring, 1991 through spring, 1994.

This study is being conducted within the Lick Creek Resource Demonstration Area, Bitterroot National Forest, in conjunction with two companion studies: 1) "Evaluation of Shelterwood Cutting and Prescribed Burning for Enhancing Multi-Resource Values of Second-Growth Ponderosa Pine Stands", conducted by Steve Arno, and 2) "The Impact of Different Fire Treatments on Survival and Growth of Thinned, Immature Ponderosa Pine" conducted by Mick Harrington. Clint Carlson, Missoula FSL, is the overall project coordinator.

This report will be divided into three parts: 1) Reconnaissance and Plot Installation (1991), 2) Post-Treatment TSI and Documentation (1992), and 3) Initial Post-Treatment Measurement of Response Variables (1993-1994).

Reconnaissance and Plot Installation

Development of the Lick Creek Research Demonstration project began in the spring of 1990 through consultations with Bitterroot National Forest, Darby Ranger District, Intermountain Research Station, and University of Montana personnel. Work started in the spring of 1991 with several reconnaissance trips to the Lick Creek area with the previously-mentioned cooperators (Carlson, Arno, Harrington). These trips were used to discuss research needs related to sustainable ecosystem management, plan research activities, and find suitable stand conditions for conducting the proposed research activities.

The objective of the overall Lick Creek project is to implement alternative harvest cutting and prescribed burning regimes whose effects roughly emulate natural processes. The goal of these regimes is to approximate pre-1900 conditions, ie. reestablish/perpetuate ponderosa pine as the predominant species, develop/maintain uneven-aged stand structures, and reduce/recycle forest floor materials.

Reconnaissance of the Lick Creek area identified a stand with characteristics (predominantly ponderosa pine, uneven-aged stand structure) appropriate for the objectives of this particular study, which is to evaluate the effectiveness of the individual tree selection method and prescribed underburning for maintaining ponderosa pine in its historic role as a dominant seral species, at low to moderate densities, in uneven-aged structures. To this end, three treatment combinations are being evaluated in this study: 1) individual tree selection cutting,

with prescribed underburning, 2) individual tree selection cutting, without underburning, and 3) control, with no cutting or burning.

A more detailed reconnaissance of the approximately 100-acre study site yielded three reasonably homogeneous, approximately 10-acre parcels to be used in the study. Each of the three parcels is being used as an experimental block, since one parcel is above the main contour road, one below the road, and a third about a quarter mile west of the other two blocks. The study is based on a randomized complete block design. Each block is comprised of three 2.4-acre (4-ch x 6-ch) treatment units, with one replicate of each treatment randomly assigned to the three units.

During July and August of 1991, a 100 percent tree tally (census) was conducted by one-inch diameter class, tree condition (crop, acceptable, non-crop), and species within each 2.4-acre treatment unit. Crop trees were defined as trees with >50 percent crown ratio, no physical defect, and no insect or disease damage; acceptable trees were trees with 35-50 percent crown ratio, good form or only minor physical defect, and no insect or disease damage; noncrop trees were trees manifesting one or more of the following: <35 percent crown ratio, poor form or significant physical defect, and/or significant insect or disease problems. The one-inch diameter tally for each unit was subsequently condensed into broader four-inch classes for use in prescription development, and to facilitate marking the respective prescriptions in the field.

The prescriptive elements for the individual tree selection prescription are shown in Table 1 for the two treatments involving cutting.

Table 1. Prescriptive elements for the individual tree selection prescription used in the Lick Creek study to achieve target stand structure, density, and maximum tree size goals.

Residual basal area = 50 ft^2/ac
Maximum tree diameter = 20 inches
Diameter distribution (q) = 1.2 (4-inch classes)
Cutting cycle = 20 years
Species composition = PP>DF (10-20% DF maximum)

In September 1991, leave trees were marked with plastic flagging in each of the six units (two units per block) randomly assigned a cutting treatment. Between late fall of 1991 and June of 1992, vandals removed or changed the marking of leave trees in a sporadic fashion over significant portions of the study area, requiring the units to be remarked to ensure the integrity of the study. With concurrence from the contract logger, we also relocated and reflagged all skid trails in the six cutting units, because the locations initially flagged would have resulted in unnecessary removal or damage to a considerable number of leave trees. This change was necessary because neither the sale administrator nor the logger had previous experience administering or harvesting selection cutting prescriptions.

Post-Treatment TSI and Documentation

Logging of the selection units occurred later than planned (late summer-fall, 1992), hence post-logging work could not begin until logging was completed in mid-October. Harvest activities destroyed most unit corners, requiring us to resurvey the units in late fall to establish new corners and boundary markers. Fifteen permanent plot centers (marked with 0.5" x 24" re-bar extending approximately one-foot above the ground) were established on a 3 x 5 chain grid in each of the nine units (Appendix A). These plot centers are used as reference points for sampling regeneration, overstory competition, and soil nitrogen content.

Post-harvest timber stand improvement (TSI) work on the selection units was expected to be accomplished by NFS (district) personnel. This did not happen, so we performed the TSI work ourselves during December, 1992, which involved felling and slashing all trees $\leq$7 inches dbh in the six logged units.

Initial Post-Treatment Measurement of Response Variables

Upon completion of TSI work, all remaining leave trees were tagged and measured for diameter before the onset of diameter growth in the spring of 1993. All trees $\geq$1.6-in dbh in the six treated units and comparable "crop" trees in the three control units were tagged at dbh and measured for diameter to the nearest 0.1 in. (Each of the three control units were leave-tree marked as if to be harvested, which will allow for more accurate determination of competition effects in the future, since among-treatment comparisons will be based on trees that were of similar

size, vigor, and spacing at the beginning of the study). All tagged trees were recorded by species, assigned a crown class, and rated for vigor using Keen's ponderosa pine vigor classification. If present, physical defect, logging damage, or other problems were also recorded.

All trees ≤5.5-in dbh in the six harvest units, and all "crop" trees ≤5.5-in dbh in the three control units were pole-measured for height, crown length, and past five-year height increment. A 20-percent sample of trees >5.5-in dbh in the treated units (and 20 percent of "crop" trees >5.5-in dbh in the control units) were randomly selected and measured for height and crown length using a clinometer. All additional (non-tagged) trees in the three control units were measured for diameter only.

The three units (one in each block) randomly assigned the post-harvest underburning treatment were burned in mid-May, 1993. Mick Harrington, Intermountain Fire Laboratory, prescribed the intermediate-intensity burns. Burning was conducted by a crew from the Bitterroot NF under the co-supervision of Mick Harrington and Bob McKee, Darby RD fire specialist.

Soil samples (referenced to permanent plot center numbers 2, 4, 6, 8, and 10) were collected from each of the three burn units immediately before burning and shortly after burning (mid-May), and two months later (mid-July). Samples were also collected in the six unburned units (3 cut/no burn, 3 control) in mid-May and July. Samples were collected by Mick Harrington, a cooperator in the overall study, and analyzed for available nitrogen under Harrington's supervision at the Intermountain Fire Laboratory.

During the summer of 1993, all trees in each of the three burn units were surveyed for: 1) intensity of fire effects in each of four quadrants on the lower bole, 2) duff reduction around the bole, and 3) distance to, and diameter of, burned out stumps. We used the same methodology and field data forms for this inventory as did Mick Harrington in the commercial thin units (Appendix B). All trees manifesting crown scorch had previously been measured to the base of the live crown, and were remeasured to the base of the remaining green crown after burning.

All tagged trees in each of the nine units were surveyed for beetle activity during the fall of 1993. Beetle hits were counted in each quadrant of the lower bole, and rated as pitchouts or dry hits. We used the same methodology and field data forms as did Mick Harrington for a similar survey in the commercial thin units (Appendix C).

A 100 percent mortality survey was conducted in the late fall of 1993 to identify all trees that had died in the first year after harvest. Dead trees were recorded by 1-inch diameter class, species, and cause of death.

Foliage samples were collected in April, 1994, immediately before growth started, from three trees in each of three diameter classes (2-5 inch, 9-12 inch, and 17-20 inch) in each treatment unit, for a total of nine trees per/unit, and 81 trees total. Using a .22 caliber rifle, the end of a lateral branch was shot out of the upper 1/3 to 1/2 of the uphill side of the crown of each sample tree. Only the needles from the immediate past

year's growth were removed for analysis. Needles were removed by firmly clasping them against the branch and twisting. Needles were immediately placed in paper bags and labeled as to tree number, treatment, and block. Samples were subsequently analyzed for C-H-N at the University of Idaho's Holm Research Center.

We now have in place a study consisting of three blocks with three treatment units each [individual tree selection cutting with prescribed underburning, individual tree selection cutting without underburning, and control (no cutting or burning)], for a total of nine 2.4-acre (1-ha) treatment units. All trees have been tagged, measured, and rated for vigor and crown classification. We are now in a position to monitor treatment effects on growth, insect and disease susceptibilty, regeneration, and nutrient status well into the future.

In the appendices which follow, preliminary summaries or results are presented relative to stand structure, species composition, stand density, scorch damage, mountain pine beetle damage, and foliar nitrogen content.

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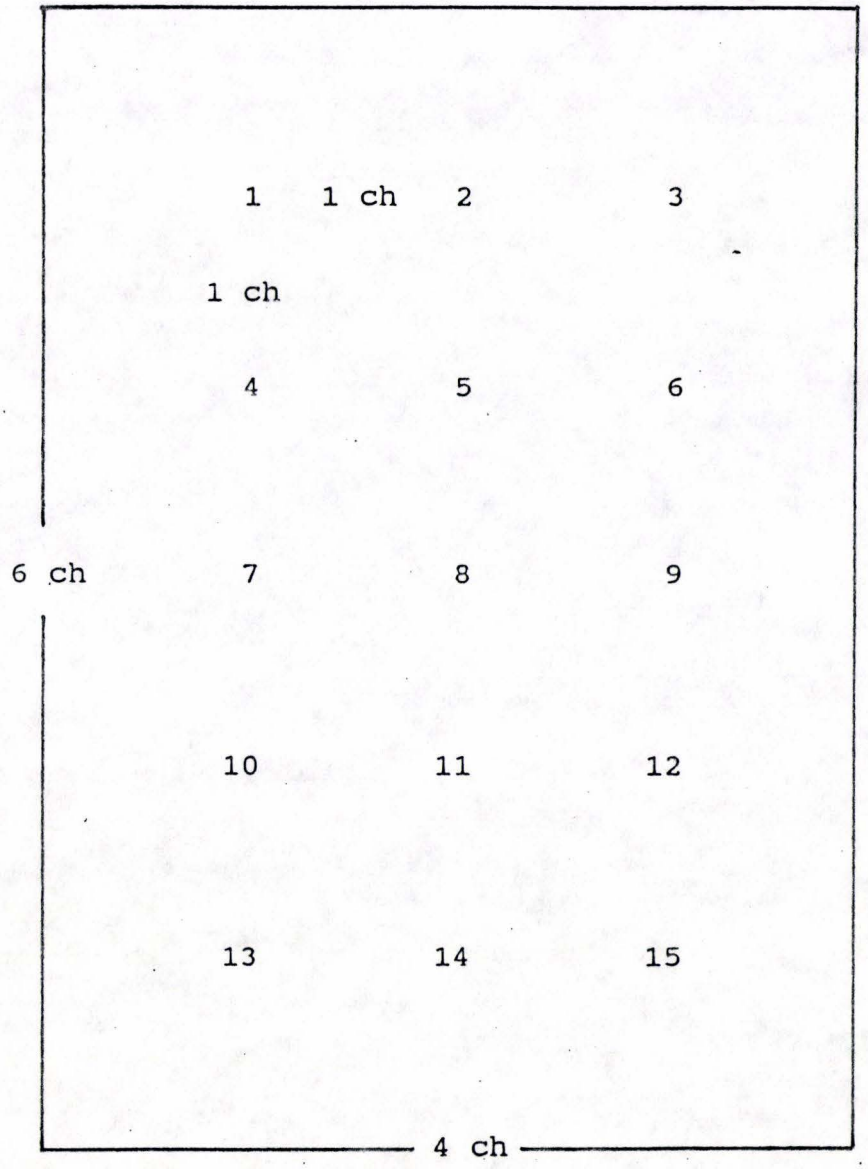
APPENDIX A - PERMANENT PLOT CENTER MAP

Schematic diagram of a 2.4-ac (1.0-hectare) treatment unit, with grid of 15 permanent plot centers.



Block_____ Crew_____

Unit_____ APPENDIX B - FIRE DAMAGE SURVEY FORM

Plot_____ Date_____

Crown Characteristics = Topo-angle To each position.

Bark Char: N = None; L = light char, bark features still evident; M = moderate uniform blackening with fissures lighter; D = Deep charring with burned bark.

Dia. stump B.O./dist from bole: surface diameter in feet of stump burn-out hole / distance from bole.

Grnd Char: Diameter in feet around bole burned to mineral soil.

	Crown Characteristics					Bark Char				Ground		
Tree #	Tree Base	Crown Base	Live Base	Scorch Top	Tree Top	Down-hill	Left Side	up-hill	Right Side	Dia. stump Burn out / Dist. bole	Grnd char	Comments

APPENDIX C - MOUNTAIN PINE BEETLE DAMAGE SURVEY FORM

OCK _____ CREW_____

UNIT _____ DATE _____

PLOT _____

SKID TRAIL: Width = _____ Length = _____ Area = _____
SKID TRAIL: Width = _____ Length = _____ Area = _____

Small tree tally (> 1 ft and < 4.5 ft tall) 1/100th acre (11.8 ft radius)

	DF	PP	OTHER ( )
Pre-treatment			
Post Harvest			
Post Burn			

Record information below for trees > 4.5 feet tall in a 1/10th acre plot (radius is 37.2 feet).

|—INSECT DAMAGE—|

Tree #	Spc	DBH	Pitch Tubes	Dry Frass Hits	Mechanical Scars	Comments

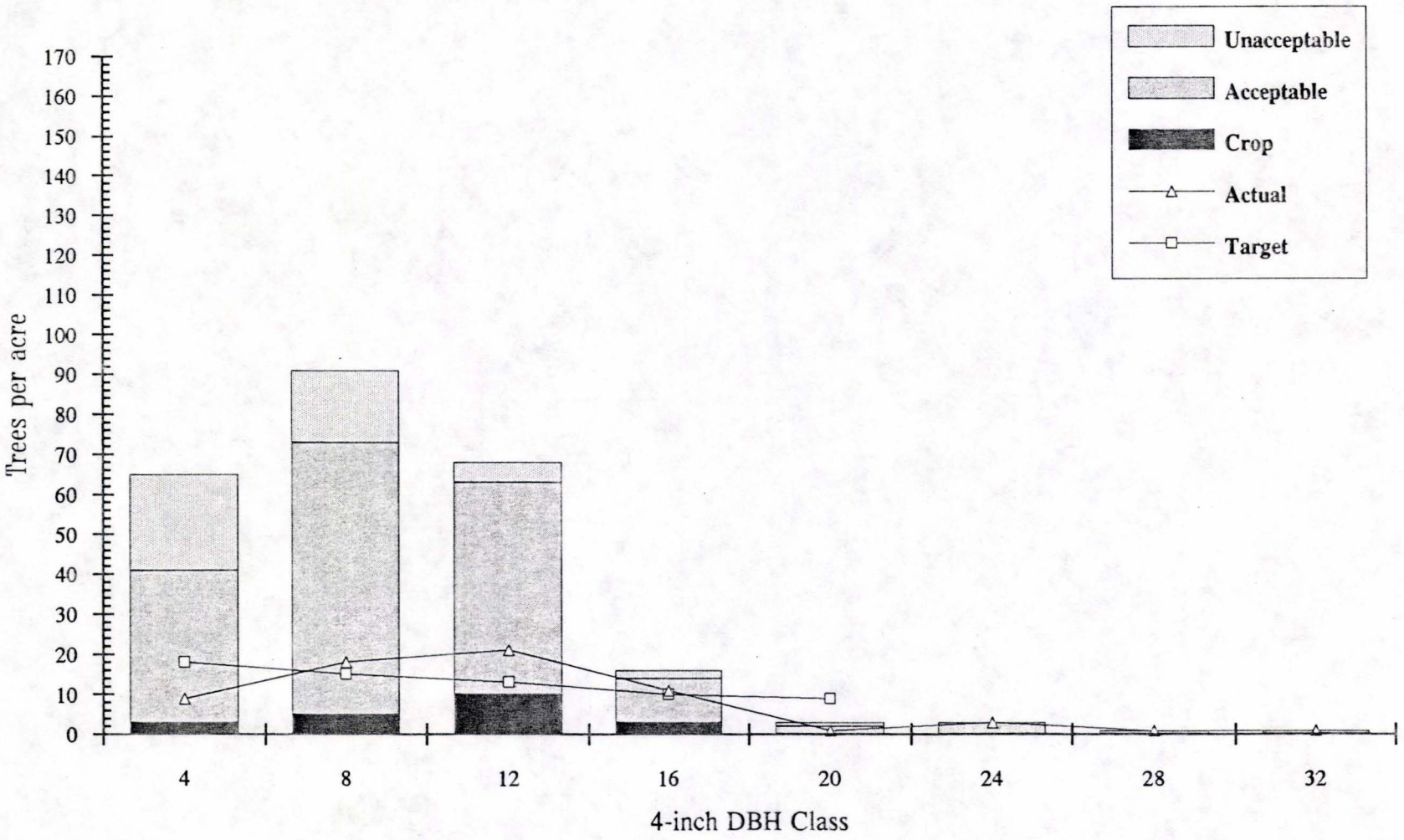
APPENDIX D - STAND STRUCTURE

Stand tables for each of the nine 2.4-ac study units appear in the pages which follow. Trees per acre are displayed by 4-inch DBH classes, based on a 100 percent pretreatment inventory. The total height of the bar for each DBH class represents the total number of trees in that class, regardless of condition; the intermediate bar represents all trees that are of acceptable or "crop" tree quality; and the lower (black) bar represents the much smaller number of trees that are of crop tree quality (i.e. $\geq$50% crown ratio, plus no visible signs of insect damage, disease, or physical defects such as crook, sweep, or forking).

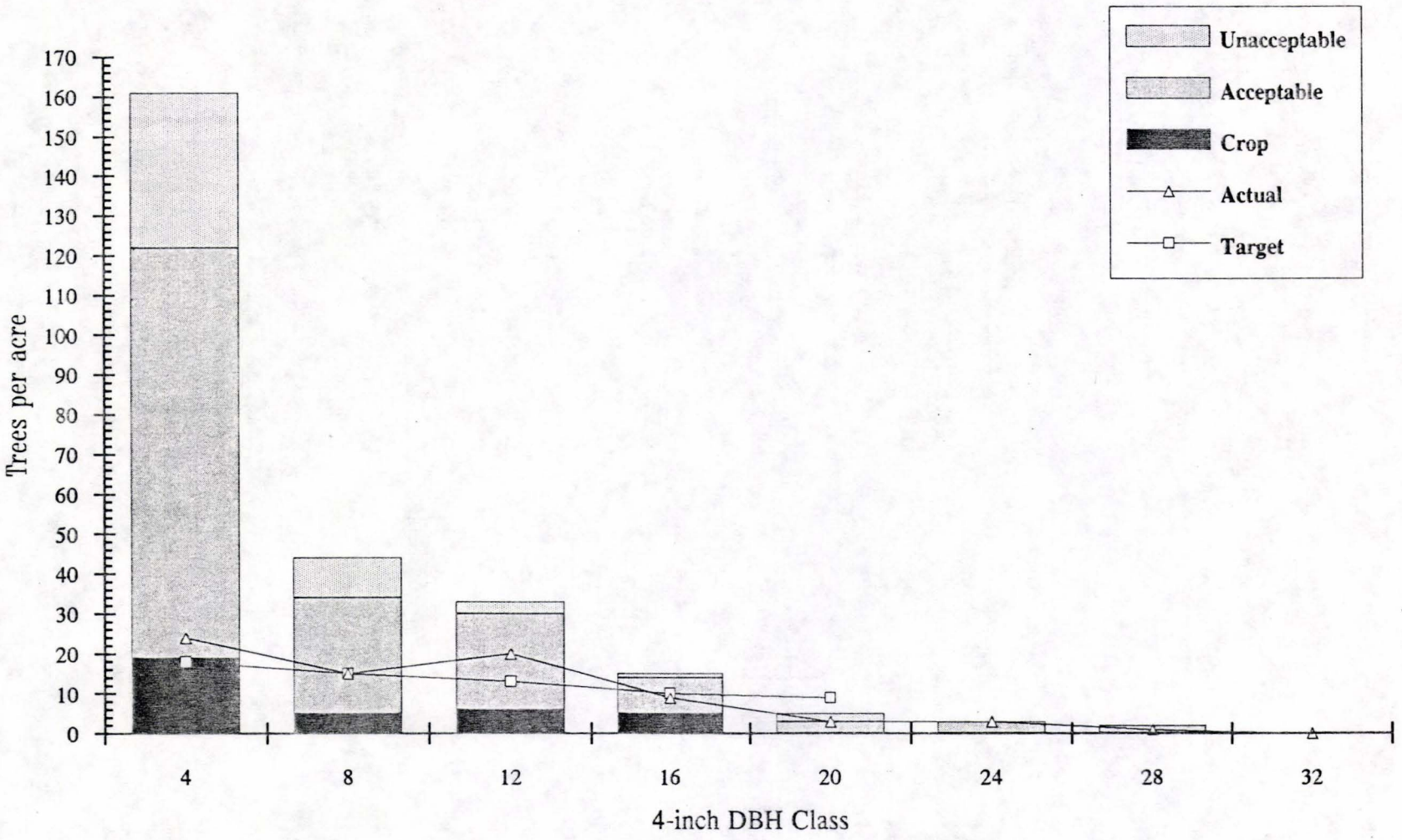
The line with the square symbols in each stand table represents the idealized diameter distribution of the "target" stand based on the individual tree selection prescription detailed in Table 1.

The line with the triangular symbols in each stand table represents the actual number of trees that were tagged in each diameter class following harvest. Despite the obvious pretreatment surplus of acceptable or better trees in the 4-inch class in all stands, the actual number of tagged trees fell below the target in most due either to juxtaposition (clumping) or logging damage. There was a deficit of acceptable or better trees in the 20-inch class in all stands, so additional trees in larger classes (i.e. 24-inch, 28-inch, etc.) were retained to make up this deficit.

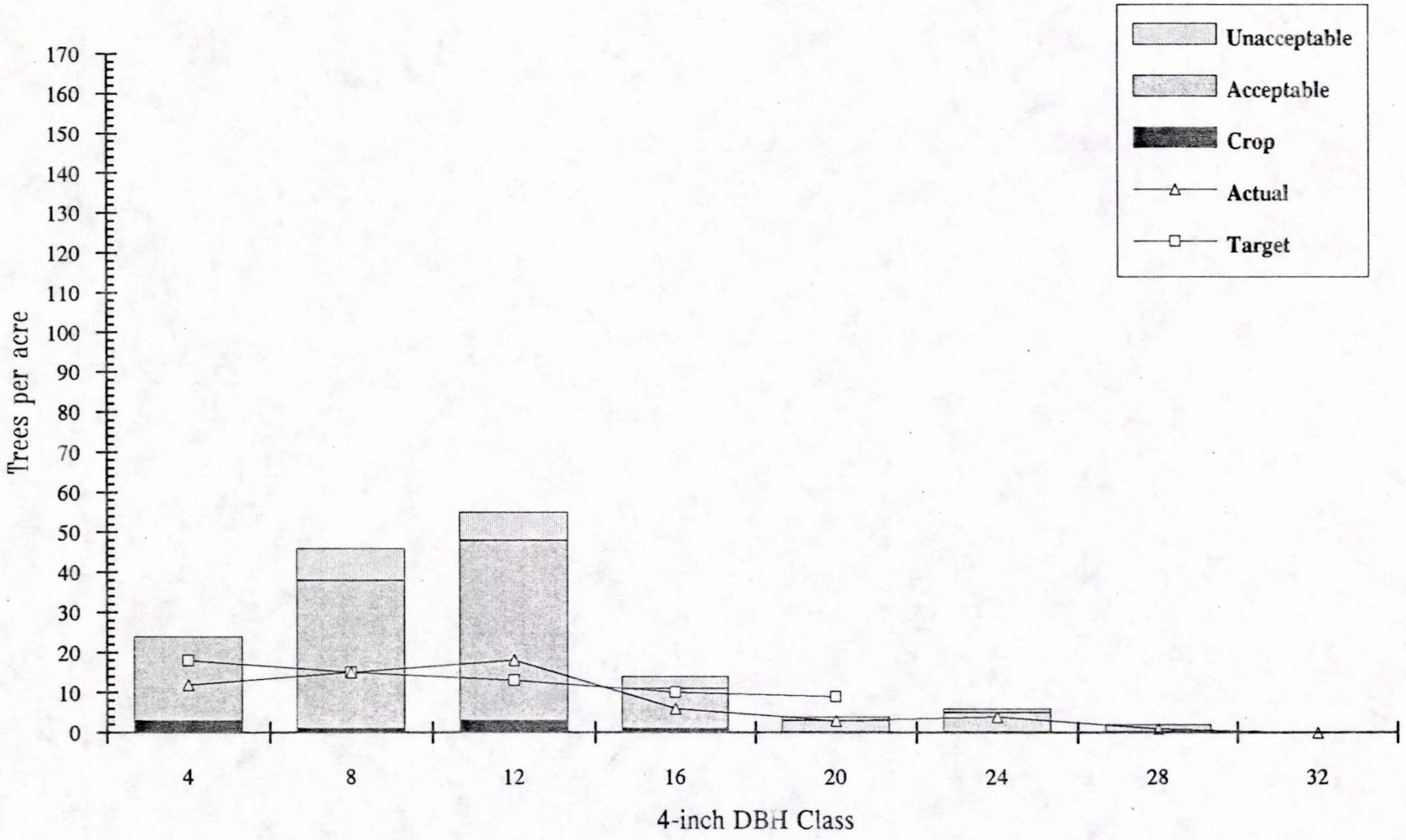
Lick Creek, Block 1, Unit 1
(burn, single unit, below road)



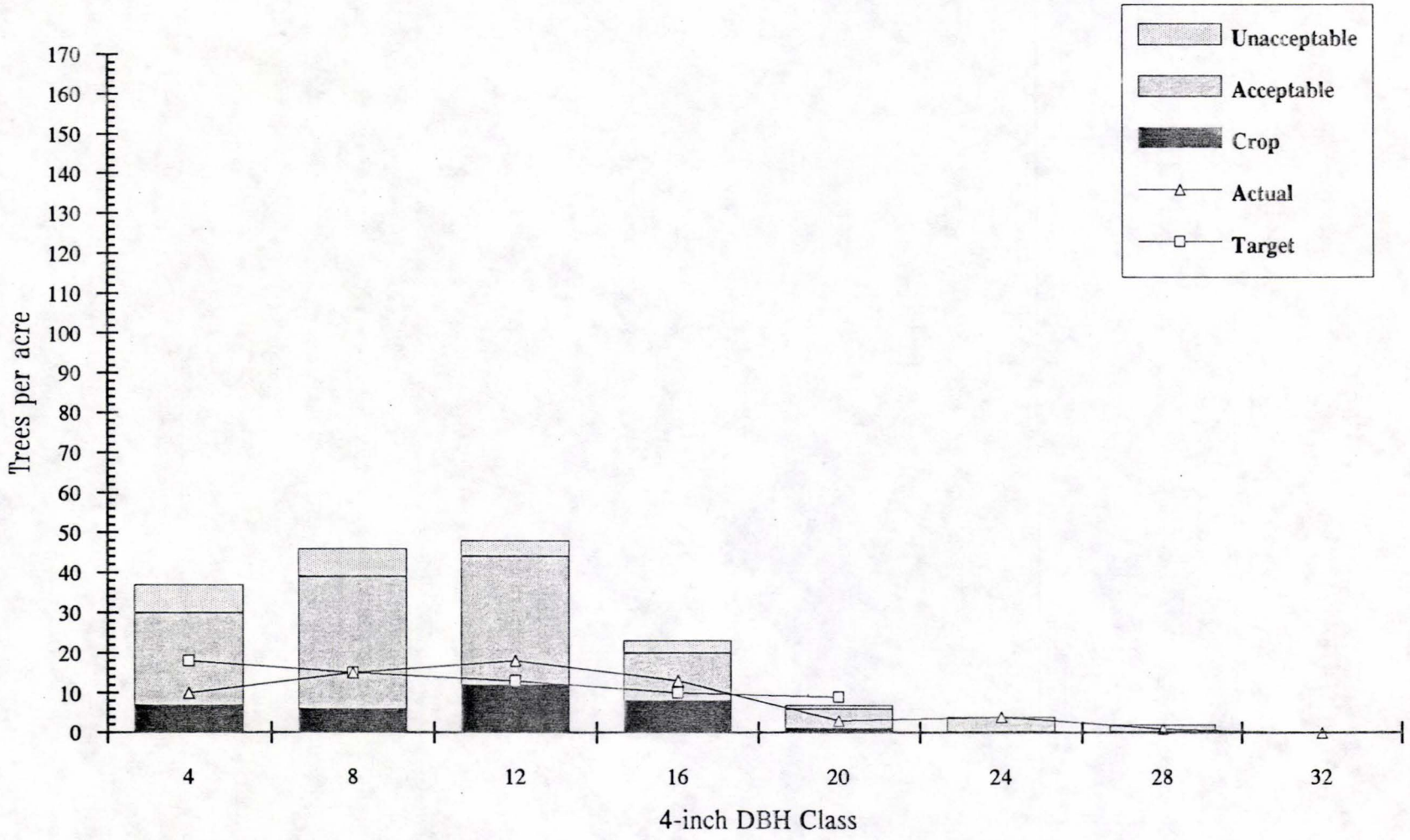
Lick Creek, Block 1, Unit 2
(scarify, east pair, above road)



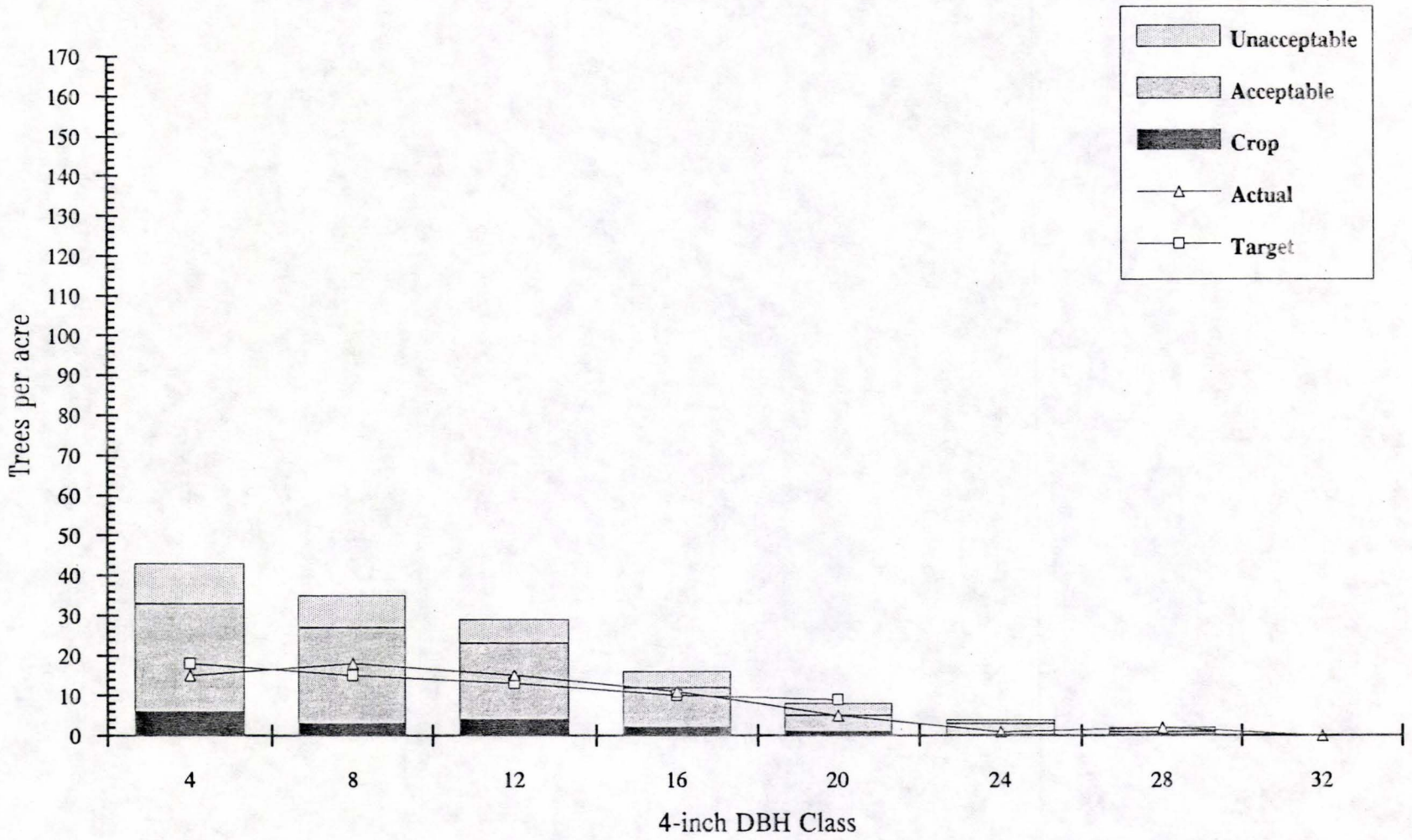
Lick Creek, Block 1, Unit 3
(control, west pair, above road)



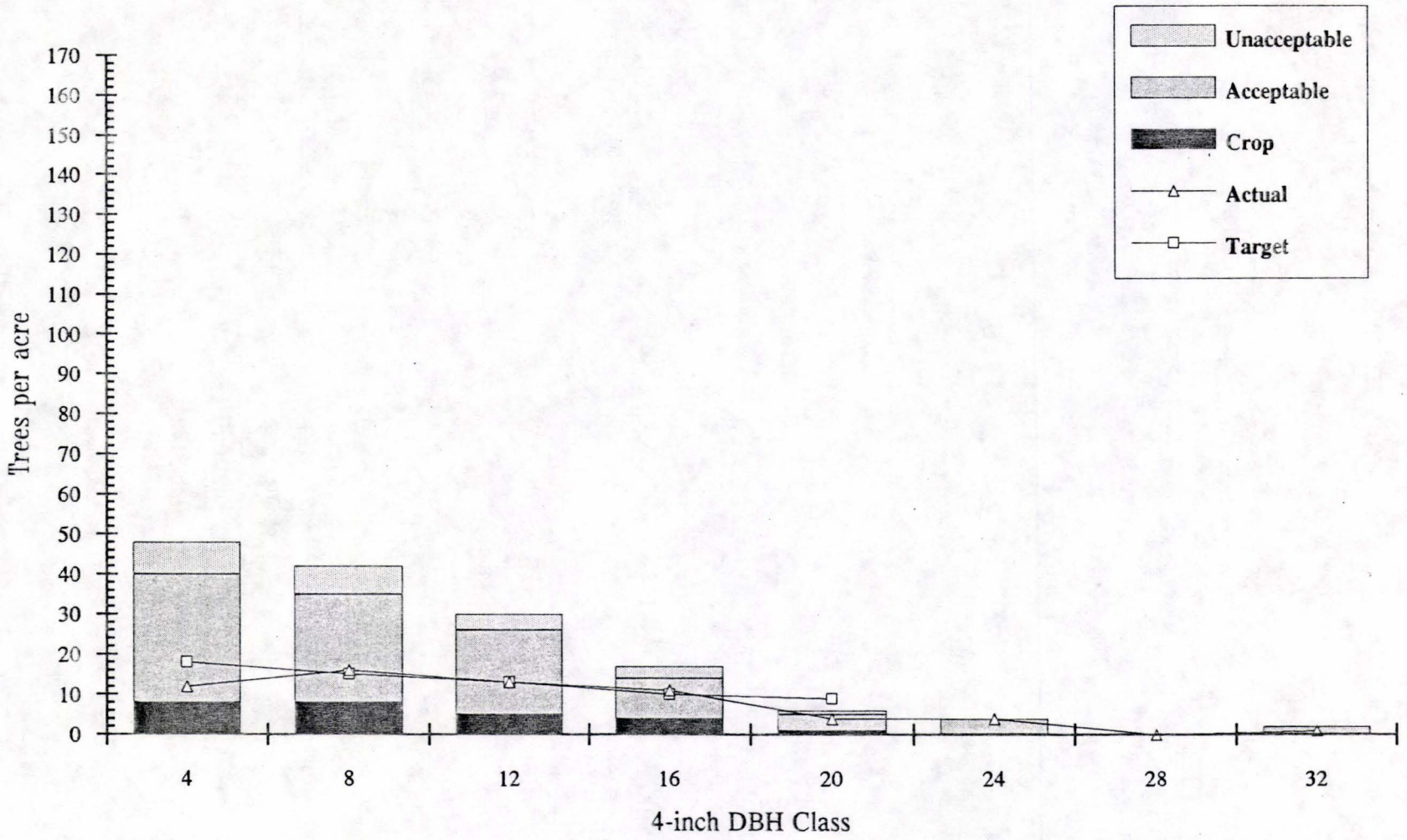
Lick Creek, Block 2, Unit 1
(burn, west unit, above road)



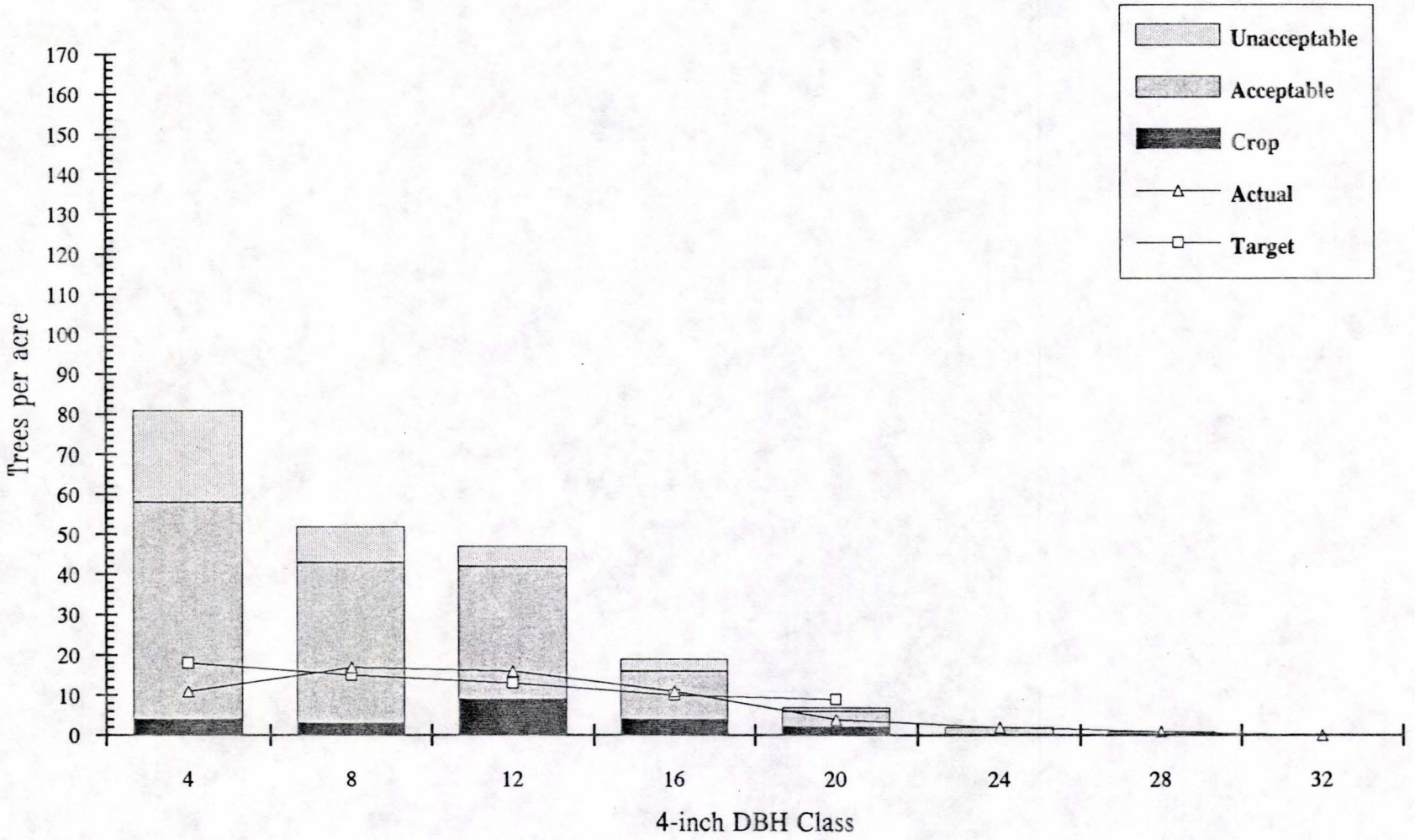
Lick Creek, Block 2, Unit 2
(scarify, east unit, above road)



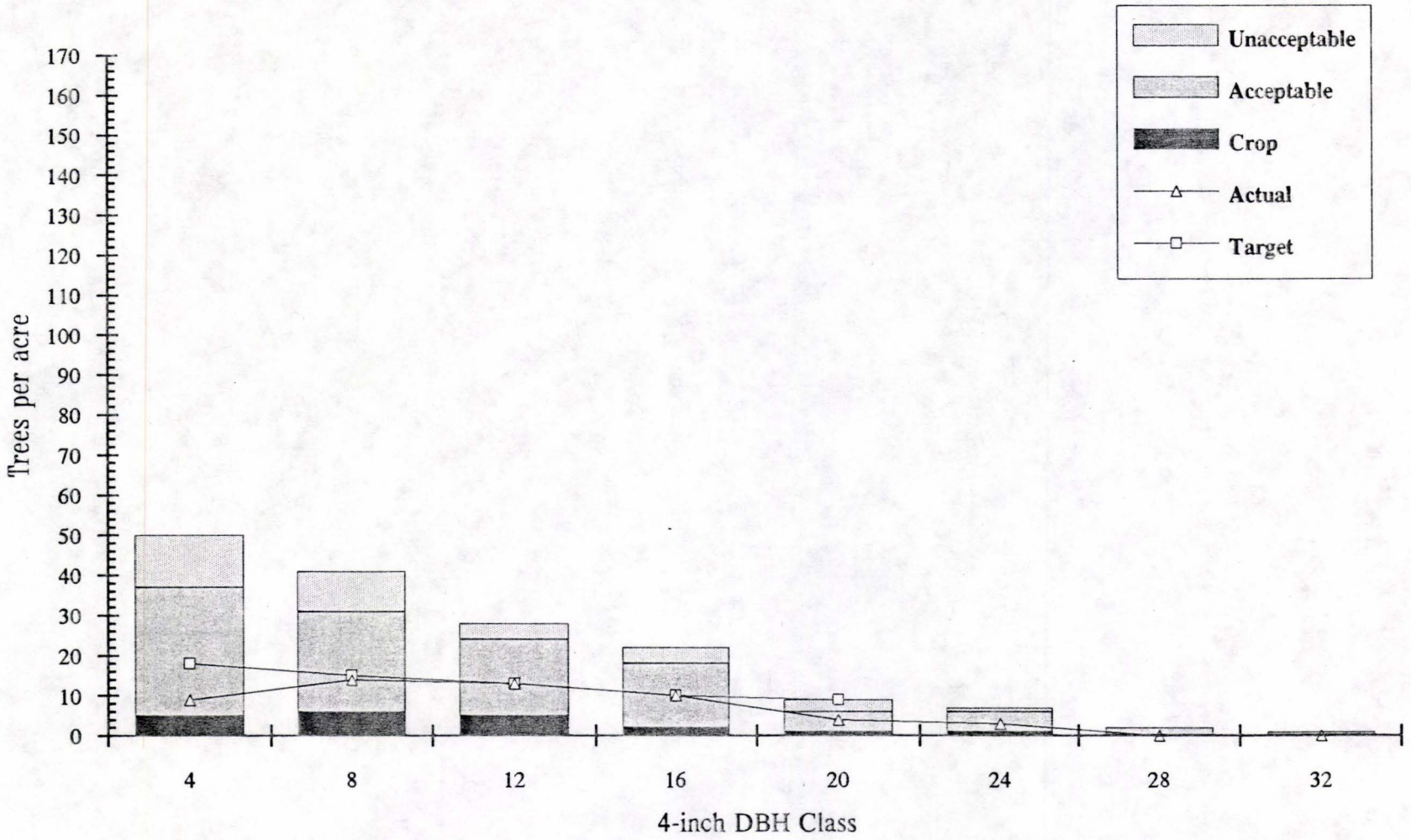
Lick Creek, Block 2, Unit 3
(control, middle unit, above road)



Lick Creek, Block 3, Unit 1
(burn, middle unit, below road)



Lick Creek, Block 3, Unit 2
(scarify, west unit, below road)



APPENDIX E - SPECIES COMPOSITION

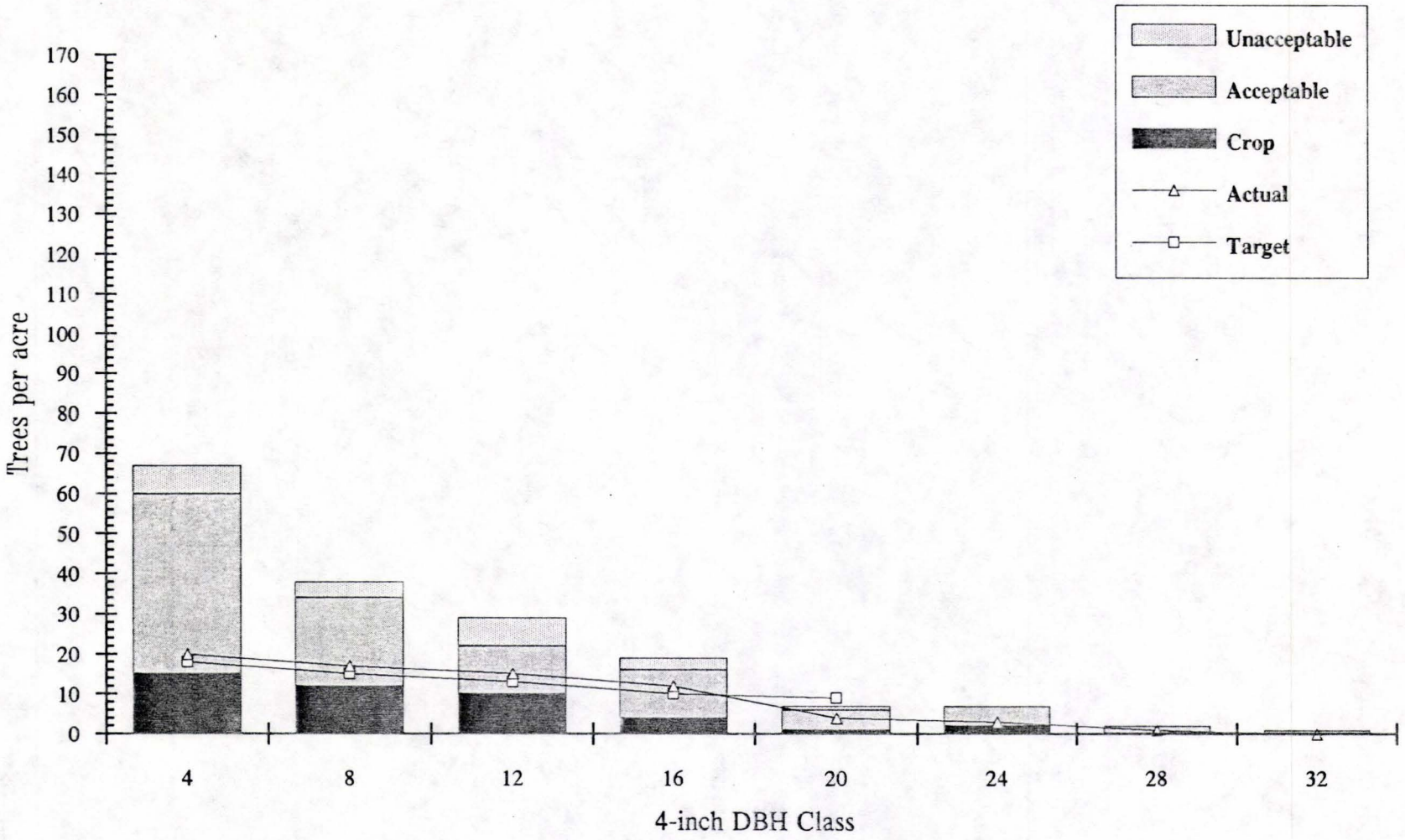
Table 2. Douglas-fir composition (percent) by treatment and 4-inch diameter class.

	Diameter Class					
	4-in	8-in	12-in	16-in	20-in	Mean
	percent					
Cut/Burn	5.6	0.0	2.3	11.6	4.5	4.2
Cut/No Burn	4.3	2.7	12.0	18.6	3.4	8.1
Control	7.5	2.6	20.0	18.8	8.3	11.3

Table 3. Douglas-fir composition (percent) by experimental block and 4-inch diameter class.

	Diameter Class					
	4-in	8-in	12-in	16-in	20-in	Mean
	percent					
Block 1	7.3	3.5	19.6	41.6	10.5	14.2
Block 2	2.2	0.0	0.0	0.0	0.0	0.5
Block 3	7.3	1.7	10.5	13.4	7.4	7.3

Lick Creek, Block 3, Unit 3
(control, east unit, below road)



APPENDIX F - STAND DENSITY

Table 4. Target residual basal area by experimental block, treatment, and 4-inch diameter class (**in bold**), and actual residual basal area following individual tree selection cutting and subsequent timber stand improvement cutting.

	Diameter Class					
Block 1	4-in	8-in	12-in	16-in	20-in	Total
	ft²/ac					
Target BA	**1.5**	**5.2**	**9.8**	**14.5**	**19.0**	**50.0**
Cut/Burn	1.0	6.4	12.9	13.2	17.6	51.1
Cut/No Burn	1.6	5.0	12.9	11.2	20.0	50.7
Control	0.8	4.7	11.2	10.2	24.5	51.4
Block 2						
Target BA	**1.5**	**5.2**	**9.8**	**14.5**	**19.0**	**50.0**
Cut/Burn	1.0	5.6	11.5	14.0	20.8	52.9
Cut/No Burn	1.3	5.3	10.5	13.9	20.2	51.2
Control	0.8	4.6	9.3	15.3	19.8	49.8
Block 3						
Target BA	**1.5**	**5.2**	**9.8**	**14.5**	**19.0**	**50.0**
Cut/Burn	1.3	5.6	10.6	14.2	19.3	51.0
Cut/No Burn	1.1	5.2	9.4	12.7	21.6	50.0
Control	1.6	5.1	9.9	14.5	18.7	49.8

APPENDIX G - SCORCH DAMAGE

Table 5. Average intensity of burn damage to tree boles on each of four sides (quadrants) in the cut/burn units, by experimental block.

Intensity (None = 0; Light = 1; Moderate = 2; Heavy = 3)

	Quadrant			
	Downhill	Left	Uphill	Right
Block 1	0.65	0.68	0.76	0.81
Block 2	0.47	0.65	0.97	0.84
Block 3	0.76	0.90	1.20	1.10
Mean Intensity	0.62	0.74	0.97	0.91

Table 6. Percent of trees receiving crown damage by scorching in the cut/burn units, by experimental block and 4-inch diameter class.

	Diameter Class					
	4-in	8-in	12-in	16-in	20-in	Mean
	percent					
Block 1	27	12	2	4	0	9
Block 2	13	31	16	10	0	16
Block 3	46	46	24	17	30	33
Mean	29	30	13	11	14	19

APPENDIX H - MOUNTAIN PINE BEETLE DAMAGE

Table 7. Percent of trees attacked by the mountain pine beetle, and number of hits per attacked tree in the two selection cutting treatments, by experimental block.

	Cut/Burn		Cut/No Burn	
	% of trees attacked	hits per attacked tree	% of trees attacked	hits per attacked tree
Block 1	25	4	2	19
Block 2	24	6	8	5
Block 3	30	9	5	8
Mean	26	6	5	9

Table 8. Percent of trees with beetle hits on each of four sides (quadrants) of the bole, in the two selection cutting treatments, by experimental block.

	Cut/Burn				Cut/No Burn			
	Quadrant				Quadrant			
	Down	Left	Up	Right	Down	Left	Up	Right
	percent				percent			
Block 1	12	11	16	9	2	1	1	1
Block 2	13	12	12	12	4	4	4	4
Block 3	22	21	24	19	3	4	2	2
Mean	16	15	17	14	3	3	2	2

APPENDIX I - FOLIAR NITROGEN CONTENT

Table 9. Foliar nitrogen content immediately before initiation of growth in April, 1994, one year after burning, by treatment and size-class (sapling, immature, mature).

	Size Class			
	Sapling 2"-5"	Immature 9"-12"	Mature 17"-20"	Mean
	% N content			
Cut/Burn	0.99	1.06	0.91	0.99
Cut/No Burn	1.07	0.99	0.87	0.98
Control	1.02	0.86	0.82	0.90
Mean	1.03	0.97	0.86	0.96